Conclusion.

If the field or beds have been well established and well cared for, there is every reason to expect that they shall be productive for many years. A field planted in 1852 is still in existence in California.

Asparagus canning is a very important industry in America; and it is now established on a sound commercial basis. "Conover's Colossal" is practically the only variety grown there for that purpose.

THE ROOT BORER AND ITS PARASITE.

H. W. Davey, F.E.S., Inspector, Vegetation Diseases Acts.

The Apple Root Borer (*Leptops Hopei*) is, in many districts of the State, one of the most formidable enemies of the fruit industry, and has exercised the minds of experts and growers alike in trying to determine an effective remedy against its ravages.

The beetles, on emerging from the soil, generally ascend the tree on whose roots they have been feeding during their larval existence. The female, after mating, seeks the leaves on which to deposit her eggs, which vary greatly in number, often reaching as many as 150. The incubation period of the eggs is about three weeks, and the major brood occurs during the spring, but the writer has seen fertile eggs as late as 25th March, and is of opinion that a not inconsiderable number is produced right throughout the year. Not only are the eggs deposited on the leaves of fruit trees, but they have been found on weeds, crops, hedges, &c., so that the beetle has a wide range for the deposit of her eggs.

The newly-hatched grub immediately descends and burrows into the ground until it reaches its normal haunts among the roots. In spite of trapping the beetles and spraying the food plant of this borer with arsenical poisons, the menace of this particular pest is in no way abated.

Soils of a heavy stiff nature are eminently suitable to the root borer, owing to the peculiar way in which the larva feeds. It does not bore into the roots of the trees, but rather flutes or grooves them, so that three sides of the tunnel in which the larva has free movement is formed by the root, and the remaining side by the stiff, compact clay. On the other hand, loose sandy soils are unsuitable owing to the grit continually falling in from the tunnel walls to the injury of the insect. After becoming full grown, the larva usually retreats to the highest part of its tunnel, where it pupates. In its native haunts, this insect is probably kept somewhat in check by the difficulty the newly emerged and scarcely hardened beetle would have in forcing its way for some considerable distance through soil caked hard and unbroken in any way, whereas, in the orchard, through the ameliorating influence of cultivation, its path from the depths below is made easy. When we remember also, that, with all insects, the change from the pupa to the imago state is always attended with great risks, it seems to the writer that the cultivated soil is a great and unavoidable factor in the increase of the beetle.

As the borer only works in stiff soils, it is useless to attempt to suppress the pest by means of the injection of poisonous fumes into the soil, as the clayey nature of the soil would prevent the fumes from permeating to any considerable extent. Experiments carried out, by direction of the Chief

Inspector, by the other inspectors and myself show this to be the case. In his report, Inspector Hammond states :—

Owing to an improvement in the growth of the trees some time after the injection of carbon fumes, it was erroneously attributed to the destruction of the borers at the roots, but Massey points out that, though the carbon fumes destroy the nitrifying bacteria of the soil, they also destroy all the forms of bacteria, amongst which are those that prey upon the nitrifying ones, and these latter, when again introduced, multiply much more rapidly than the others, and stimulate the growth for a short period.

On 24th March I treated four Five Crown apple trees in the same orchard. I made holes with a crowbar, as the injector would not put the carbon down sufficiently deep. I had ascertained that, in soil such as the one being treated, no grubs live within about 20 inches of the surface. I gave from 18 to 21 injections to each tree, using the Pal injector; ⅓ to ½ oz. of bi-sulphide being injected into each hole. The holes were about 30 inches apart, and 20 inches from trunk of tree, and were within a circle of about 9 feet in diameter. The quantity of bi-sulphide used for each tree was from 6 to 10½ ozs.

On 25th May, about eight weeks later, I partly grubbed one of the trees treated on 24th March. A careful examination of the soil and roots was made, and five live grubs and one dead one were found. Three of the live grubs were nearly full grown, one about half grown, and one very small. The dead grub was full grown, and in a good state of preservation. None of the grubs were found nearer than 24 inches to the surface. The dead grub was found 30 inches below the surface.

I partly grubbed two other trees, not treated, for the purpose of comparing them with the one treated. I found four grubs and a beetle from 24 to 30 inches below the surface in the clay in one tree, and one grub and one beetle were found in the other. No dead grubs were found in the untreated trees, but, apart from this, there was no difference in the appearance of the grubs. In this case the bi-sulphide did little or no good as far as I could see.

Inspector Cock, of Bendigo, has carried out experiments in root treatment, by the application of bi-sulphide of carbon; and, in addition, gas lime, lime, cyanide of potassium, and cyanide of soda, with no appreciable benefit.

Arsenical Spraying.

There is evidence that arsenical spraying is partially effective. Inspectors Farrell and Hammond reported that they have found as many as thirty dead beetles under trees sprayed with arsenate of lead, whereas prior to the use of this material no dead beetles were to be found. Though spraying may kill many of the beetles, it cannot, in my opinion, be regarded as other than a factor, and probably a small one, in dealing with this insect. Even if the beetles consume sufficient of the sprayed foliage to get a fatal dose, death in insects is always slow from arsenical poisons.

The first thing that takes place on emergence from the soil is the copulation of the sexes, so, even if the female were killed by poison, she would be fertile, and probably able to eject her eggs (as many insects do when dying from injuries, &c.), though too feeble to draw the leaf together to protect them. On the other hand, eggs are not fully developed when beetles first emerge from the soil, and the beetles might be poisoned some time before this happens; but, notwithstanding that these creatures devour large quantities of foliage, the vitality of all insects immediately previous to egg-laying is remarkable.

In order to be successful it would be necessary to spray the fruit trees during their period of growth, as well as all herbage throughout the entire year.

Bandaging.

Bandages are of little use unless properly attended to and adjusted, as the beetles are capable of walking up clean glass almost as freely as up a

tree trunk; and many pass these collars for the purpose of egg-laying, so that the orchardist is depending on something that only stops a percentage of the beetles.

At Panmure, every tree is "collared" and attended to every morning right through the season, except in the case of gooseberry bushes. As the larvæ feed on the roots it makes little difference to them where the eggs are laid, and possibly a gooseberry bush is just as acceptable as an apple tree. It will therefore be seen that the gooseberry bushes require as much protection as the trees.

Messrs. Moore Brothers, of Vauxhall Gardens, Panmure, have for many years kept a daily account of the number of beetles killed on a 7-acre patch of their orchard of 60 acres, the only part attacked. During 1905, 14,633 beetles were trapped and destroyed. This number diminished until, in 1907, it fell to 7,190; in 1909, it increased to 15,360. Not only were these growers extremely careful in trapping the beetles, but greater attention has been given to spraying during the latter years. Still, instead of an appreciable diminution there was an actual increase of over 100 per cent. in the beetles trapped.

A Parasitical Enemy.

From my own experience, and that of growers like those referred to, it would appear that there must be some natural check to the multiplication of this insect in the native timber, otherwise our forests would be entirely depleted. The difficulty the beetle may have in emerging from the soil in the uncultivated lands would probably to some extent affect its increase, but not sufficiently to account for the comparatively little damage that it does to our forest trees. I was therefore led to the conclusion that other factors were at work towards this end, and began investigations in this direction, with the result that a parasite very deadly to the borer was discovered.

PERILITUS LEPTOPSI, VIERECK, *n.sp.*

On dissecting a female Leptops in June, 1910, she proved to be full of parasites, so live beetles were placed in observation cages. In the course of a few days parasitic larvæ emerged from these, and pupated in tiny silken cocoons all clustered together, showing at once that they belonged to the *Hymenoptera* (probably the *Braconidæ*). From these cocoons the perfect insect emerged in October, the time of year when the root borers first appear, but unfortunately before being able to obtain more beetles the parasites died. The parasite was again observed in large numbers during December at Panmure, and January at Mount Cole, near Ararat—the only places where this insect has been so far discovered.

The female parasite is furnished with a long ovipositor, with which she injects her eggs into the abdomen of the beetle. On these hatching, the minute grubs first feed on the eggs of the beetle contained in her body. Sometimes it happens that these eggs supply sufficient food during the larval existence of the parasites, which can be seen emerging from their erstwhile habitat for the purpose of pupating. Strange to say, the beetle in some cases, after the exodus of the parasite, appears healthy and active for a short time. As a rule, however, the parasites, after consuming the beetle's eggs, turn their attention to their host, and eat up absolutely everything contained in her abdomen, the beetle dying as they emerge.

During January, as far as could be discovered, only female beetles were parasitized, but later on, as this enemy of the root borer increased in numbers, the male beetle attracted their attention, and was completely eaten out by these ravenous creatures, leaving the abdomen a mere shell.

The number of parasitic larvæ contained in a beetle varies, but last season averaged 25, so that the orchardist who kills a parasitized beetle is at the same time destroying, on an average, 25 parasites. In order to give this friend of the orchardist an opportunity of determining its value, it would be advisable, instead of killing the root borer beetles, to place them in boxes having perforated zinc ends, to allow the parasites free ingress to and egress from the box. This at the same time prevents damage being done by unparasitized beetles.

The imago form of this parasite has been reared in October and also in March. Those appearing in March left the beetle as larvæ on the 25th February, and had all pupated by the next day, the perfect insect appearing on the 11th March, a matter of only thirteen days.

Numerous specimens were submitted to Mr. C. French, Government Entomologist, for his opinion; and as Mr. Arthur M. Lea, Government Entomologist of Tasmania, is regarded as a specialist on the *Curculionidæ*, specimens of the parasitized beetles were forwarded to him. In reply, a letter was received from Mr. Lea saying:—

The parasites of Leptops are certainly *Hymenopterous*, as from the specimens you sent over I have now about 100 cocoons.

Mr. Lea then suggested that, as in all probability this parasite was new to science, specimens should be forwarded to Dr. Howard, Chief of the Entomological Bureau at Washington, U.S.A., for naming and description. This was done by Mr. Lea. In further correspondence he writes:—

I think it is almost certain that the parasite is a new species, and it is certainly one of the most important that we have in Australia. It was for this reason I suggested its being sent to Dr. Howard.

The discovery of this parasite may prove of the greatest value to fruit-growers generally. It behoves all interested in the eradication of the Root Borer to study this phase of treatment, and endeavour to assist the parasite in multiplying and increase the opportunities it may have to carry out its usefulness.

The following correspondence, together with the description of the insect from Dr. Howard, is of interest, not only to the growers of this State, but to those who follow up this line of study and investigation. The writer is indebted to Mr. Lea for the outline drawing of the parasite, which is here reproduced.

Dr. Howard writes:—

I am now able to give you the determination of the parasite of Leptops. Mr. H. L. Viereck, of this Bureau, has been studying it, and has described it as *Perilitus leptopsi, n.sp.* I enclose manuscript description, which you are at liberty to publish in connexion with illustrations and any matter you may care to add to it.

Perilitus leptopsi, Viereck, n.sp

Female.—Length, 2.5mm. Compared with *P. secalis*, Haliday, as described by Marshall, this differs as follows:—Mid and hind legs beyond coxæ more or less blackish, prothorax and mesothorax mostly castaneous; abdomen beyond the petiole mostly black or blackish, basally somewhat castaneous in the middle; wings tinged with brown, veins and stigma brownish, tegulæ rather testaceous; first tergal segment nearly as long as the remaining portion of the tergum, mostly smooth and polished, postpetiole nearly as long as the petiole proper, and almost parallel sided, owing to the prominently produced spiracles, petiole proper on each side near the middle with a shallow-fossa, appearing to be due to the aciculation of the tegument at the same point, sheaths of the ovipositor blackish throughout.

Male.—Length, 2.25mm. Resembles the female, but with the thorax and abdomen almost entirely black, and with the postpetiole rather sculptured throughout.

Type.—Locality, Panmure, near Warrnambool, Australia. Type Cat., No. 13642, U.S.N.M. This species was also collected or reared as parasite of a species of Leptops at Mount Cole, Ararat, Australia, by H. W. Davey.

The larva has somewhat the appearance of Figure 12 in Ratzebury's second volume of Ichneumonen der Forstinsecten. A series of some fifty-five imagoes shows less variation than is credited to *P. secalis*, Haliday.

For the benefit of those who may not have access to Marshall's Monograph of British *Braconidæ*, it may be stated that this species belongs to the category with the first submarginal cell confluent with the first discoidal, radial cell with its tip a little nearer the stigma than the tip of the wing, and with three-jointed labial palpi.

INSECTS DESTRUCTIVE TO CROPS.

CUT WORMS.

C. French, jun., Assistant Government Entomologist.

During the past season numerous inquiries for information in regard to the above mentioned insects and the best means for destroying the same have been received. The Climbing Cut Worm (*Mamestra evingi*) has been very prevalent, grain crops, barley in particular, being badly attacked. Other Cut Worms—*Agrotis* (several species), *Heliothis armigera*, *Leucania*, and others—have also been much in evidence. Cut Worms are amongst the most troublesome insects growers have to deal with, and every year they are the cause of much destruction on farms, vineyards, and gardens. Wheat, oats, barley, maize, vines, plums, tomatoes, onions, beans, cabbages, and potatoes are all subject to attack.

Cut Worms are also known as Cut Worm Caterpillars, Looper Caterpillars, Army Worms, Take-all Grubs, &c. They are variable in colour, especially the larvæ of the Tomato Moth. The latter vary from green to yellowish, but most of the *Agrotis* are of a dirty greyish or light-brown colour, without hairs or spines, smooth, and greasy looking, often being of a similar colour to the ground in which they hibernate. Some of the cut worms feed both day and night, whilst others hibernate just under the soil, or under logs, stones, bags, bark, and rubbish during the day and feed during the night. When they are fully grown (which takes a couple of weeks), and until they are ready to pupate, the pupa is of a dirty reddish-brown colour, sometimes almost black. After pupating, they remain in the ground, in the warm weather, from ten to fifteen days before the moths emerge; in the cold weather, the period is much longer.

Life History.

There are at least two broods of cut worm moths in a season, but further observations will be necessary before the number is finally ascertained. The moths usually fly about at dusk and deposit their eggs on any suitable plant. The eggs hatch in a few days, and the young cut worms start to feed at once, any kind of green food being greedily eaten by them. Even when the grain is just sprouting it is attacked, and often they will eat right into the husk.

The coloured plate shows some of the common cut worm moths, and also two other species of closely allied noctuids (night moths). In the museum of economic entomology and ornithology of this Department are specimens of all the Victorian cut worm moths, their eggs, and larvæ. The collection may be inspected by all interested.